Pass-through from Export Prices of Vehicles: Evidence From the Norwegian Market

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Christel Nguyen

Abstract

In 1987 Paul Krugman published a paper where he points out that the presence of imperfect competition leads to pricing to market behaviour among the exporters. As such one has observed that there is a divergence in the export price and import price of the internationally traded products. Domestic production of the same traded products in the importing country will lead to imperfect competition. Since there is no domestic production of vehicles in Norway, the pricing to market, as defined by Krugman (1987), is a priori irrelevant in my case. In this thesis, I examine the perfect competition assumption in the market for vehicles based on Boug et al. (2005, 2013) and Benedictow and Boug (2012). I use of new and more updated data to see if the results are different from those in Boug et al. (2005, 2013) and to see if the financial crisis in 2008 has any impact on the pricing behaviour for the exporters of automobiles to Norway.

I estimate several equilibrium correction models using quarterly, seasonally unadjusted time series data for the sample period 1990-2012. I find that in the long run, there is complete exchange rate pass through in accordance with the perfect competition hypothesis. The estimate of the equilibrium correction term is 0.21, which is a rather moderate speed of adjustment of import prices towards long run equilibrium level in the event of a shock in the exchange rate or in the marginal costs. The estimate of the long run unemployment rate is not significant, therefore it can be interpreted as evidence of no pricing to market since the domestic condition does not have a role in the long run pricing behaviour. The short run estimate of the foreign prices in Norwegian currency of 0.27 is also very small in magnitude and says that, in the event of a shock, only 27 % will be pass through to the import price of vehicles. I also find that the financial crisis in quarter three in 2008, which hit the Norwegian economy late in the third quarter of 2008 did not give significant changes to the pricing behaviour of the exporters.

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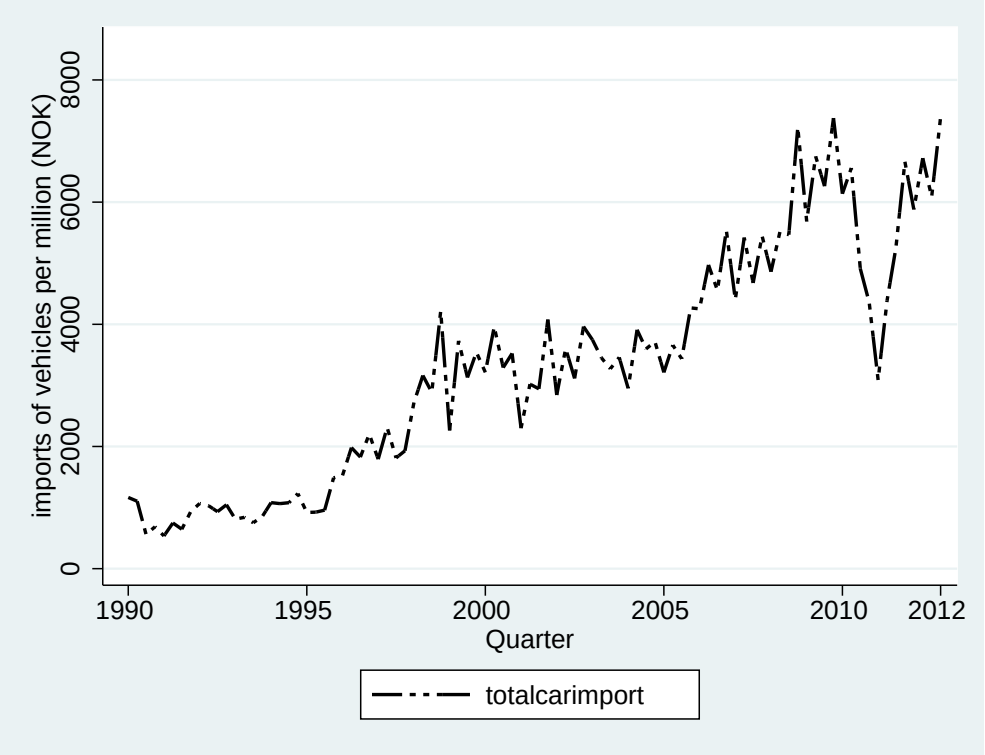
1 Introduction

Motor vehicles have become more and more important to people's life over the last decades. This is also the case for Norway. Slowly, but steadily we can observe the increasing demand for motor vehicles as many more countries in the developing world become richer and more modern. Figure 1 shows the trend in total imports of vehicles from 1990 to 2012 in Norway. We see a clear trend of increasing demand for vehicles throughout the whole period, with a major drop in the wake of the financial crisis, followed by a rapid increase thereafter returning to its normal upward sloping trend.

Figure 1: Total Imports of Motor Vehicles to Norway, 1990-2012



The literature on import prices has grown large after the seminal pricing to market paper, by Krugman (1987). For Statistics Norway, understanding how the development of import prices have evolved over time is of crucial importance. Specifically, the imports price of vehicles is of interest for Statistics Norway because imports of vehicles amount to almost one third of total imports of non-competitive imports of goods and services [1]. And developments in the import price of vehicles can have a large impact on the inflation level in the economy. Among the many publications and discussion papers on the topic are the papers that I want to highlight, Boug et al. (2005) and Benedictow and Boug (2012). These papers look into the pricing to market phenomenon and exchange rate pass-through in the market for manufacturing and vehicles and in

[1] The number is taken from the 2008 version of MODAG from Statistics Norway over non-competitive imports of goods and services

the market for clothing and textiles, respectively.

There are many studies on perfect competition and the exchange rate pass-through. The term pricing-to-market is thoroughly explained in Krugman (1987) which I later will talk more about. For now, pricing to market, as defined by Krugman (1987), is when there is not full rate of pass through to the import price of the traded product from a change in the exchange rate, the marginal costs or in the domestic conditions of the importing country. Krugman (1987) argues that the presence of domestic competition, that gives imperfect competition, leads to pricing to market behaviour by the exporters. The evidence of incomplete pass through often is argued to be linked with the pricing to market behaviour under conditions of imperfect competition and segmented markets, for which Menon (1995a), Goldberg and Knetter (1997) Gil-Pareja (2003), Herzberg et al. (2003) and Campa and Goldberg (2005) stand for, among many other researchers.

In this thesis I examine the price-taking assumption in the market for vehicles in Norway based on Boug et al. (2005, 2013) and Benedictow and Boud (2012). My aim is to see how changes in certain external variables affect the final vehicle import prices. I estimate several equilibrium correction models using data on Norwegian import prices, foreign export prices in Norwegian currency, the Norwegian unemployment rate and import weighted exchange rate currencies. Price-taking behaviour indicates that there is perfect competition in the market for motor vehicles. From economic theory, we know that if the market for internationally traded goods is perfectly competitive, the price for a product is given by the internationally traded price. This means that the price for a given type of vehicle is the same regardless of where you buy it, given the exchange rates. My two testable hypotheses are that 1) there is complete rate of pass-through from a change in exchange rate or in the marginal production costs, at least in the long run and 2) there is no change in the pricing behaviour before and after the financial crisis in 2008-2009. The alternative hypotheses are 1) that the rate of pass-through is not complete, even in the long run and 2) that there is significant changes in the pricing behaviour after the financial crisis. If hypothesis 1 is rejected, then the market for vehicles in Norway follow the same pricing-to-market idea as that for manufacturing and clothing, which are the results obtained by Benedictow and Boug (2012) for clothing.

My main contribution to the literature is a new and updated data for the variable foreign export prices in foreign currency, which is a proxy for producer marginal costs, that was used in Boug et al. (2005). This requires the collection of different data series. I first sort the data according to how well they measure producer marginal costs. Then I construct a new variable for foreign prices in foreign currency by using the Törnqvist price index as the underlying index number formulae and a merging technique commonly used by Statistics Norway. I have to gather new data, because the foreign price data provided by Statistics Norway are not available

for the period after 2005. The time series data in Boug et al. (2005, 2013) starts in 1988 and my data series starts in 1990. While Boug et al. (2005, 2013) end their estimation period in 2003, my data series extend to quarter four of 2012. Boug et al. (2005, 2013) therefore do not cover the period after the financial crisis in 2008. Extending the data series to include the financial crisis in 2008 makes it possible to investigate whether the second hypothesis holds. The extension of the data series may also provide better estimates. The rest of the thesis is organised as follows. In Section 3, I review some of the papers that have analysed on the pricing to market theory. Section 4 presents the model I am going to work on. Section 5 describes the data that are used in this thesis and how the data are collected and created. In Section 6, I go through the econometric methods and findings and Section 7 concludes.

2 Literature Review

I will now go through the main papers which this thesis builds on, both theoretically and empirically.

2.1 The Seminal Paper of Krugman (1987)

The seminal paper of Krugman (1987) describes the ”term pricing to market” as a phenomenon that arises when import prices of the traded products do not change as much as the rise, or fall, in the exchange rates. Pricing to market leads to a divergence between prices of the imported goods and services and the export prices. If pricing to market is absent, the law of one price should prevail. The law of one price states that $P^* = eP$, where P^* is the price of the same product in the exporter's currency, e is the exchange rates for the two countries and P is the price in the importing country. This means that if the law of one price prevails, the price in the exporting country is equal to the price in the importing country times the currency exchange rates for these two countries. However, observations made of import prices and export prices for certain industries suggest that prices do not follow the traditional and theoretical direction, that internationally traded goods follow a given international equilibrium price. Krugman (1987) tries to explain this phenomenon using both static and dynamic models. He concludes that the static models are not sufficient to explain this phenomenon because these models rely heavily on the assumptions of linear and constant demand elasticity. The dynamic models are better at explaining pricing to market. Krugman (1987) concludes that pricing to market does not hold in the general case, but only occurs in the market for machinery and transport equipment.

2.2 The article by Naug and Nymoen (1996)

Naug and Nymoen (1996) investigate the determinants of Norwegian import prices of manufactures. They apply data for the period 1970(Q1)-1991(Q4). Using a multivariate cointegration analysis they find that there is a long run relationship between the import prices, foreign prices, the exchange rate and the domestic unit labour cost. Their structural import price equation estimation give positive effects from growth in domestic demand and inflation and negative effects from the Norwegian unemployment rate. These results are credible due to stable estimated parameters. Theoretical models of small open economies assume that 1) changes in the world prices and the exchange rates are quick and complete pass through to the prices of imports, and 2) that conditions in the importing market are irrelevant for the growth in import prices. They find no cointegration relationships between the Norwegian import prices, the foreign prices and the exchange rate, but these three variables are cointegrated with the domestic unit labour costs. Tests of weak exogeneity show that deviations from the estimated cointegrating vector are corrected by import prices only.

I base my analysis on the articles by Boug et al. (2005, 2013) and Benedictow and Boug (2012), therefore I present these papers in more detail so that the reader can understand the background behind the research area of this thesis.

2.3 The articles by Boug et al. (2005, 2013)

Boug et al. (2005, 2013) are motivated by the large fluctuations in the exchange rates, which led to consumer price inflation dropping far below the target of 2,5 percent soon after the switch to inflation targeting in early 2001. Another motivation is the existence of both theoretical and empirical evidence that suggest low (or even zero) pass-through of exchange rate fluctuations to consumer prices that may be related to the role of distributors in the economy.

There are studies suggesting that pass-through is greater to import prices than to consumer prices, thereby the degree of pass through from a change in the exchange rate or in the marginal production costs, whether or not the system producer currency pricing or the local currency pricing is applied, which Boug et al. (2005, 2013) argue is presumably related to the role of distributors in the economy. This is a literature that follows from the work of Obstfeld and Rogoff (1995). The theory of local- and producer-currency pricing states that, if producer currency pricing holds, producers do not change their prices frequently, whereas consumers (exporters) face prices that vary one-to-one with nominal exchange rate changes due to full pass-through. If we have local currency pricing, that is, the price is set in the currency of the consumers (importers), then the opposite effects occur so that we get no (or limited) pass-through of nominal exchange rate changes to import prices (at least in the short run). This implies small effects from exchange rate changes to producer costs, to the extent that production is based on im-

ported materials, as well as to consumer prices, to the extent that consumption is based directly on imported goods and services.

Boug et al. (2005, 2013) address these issues in their empirical analyses. Boug et al. (2005, 2013) examine the exchange rate pass-through on domestic prices, production costs and mark-ups for a large number of commodities and sectors in the economy. In their appendix Boug et al. (2005) describe how they have modelled their import prices of manufactures and cars. Through estimations of import price equations and dynamic modelling of the distributors pricing behaviour with the use of a large-scale macroeconometric model of the Norwegian economy, Boug et al. (2005, 2013) find that trade margins in the distribution sector, which acts as cushions to exchange rate fluctuations, are important sources for the delay in pass-through. They also find that exchange rate pass-through to import prices in domestic currency are rapid, but incomplete even within a ten-year horizon. Through model simulations they find that pass-through of exchange rates to consumer prices is slow,but complete in the very long run, and that pass through to import prices is much quicker than to consumer prices. They also find that the pricing behaviour in the distribution sector does play some role during the first year in delaying the exchange rate pass-through to consumer prices. The results that follow from Boug et al. (2005, 2013) indicates incomplete exchange rate pass-through to consumer prices even within a ten-year horizon, which then can be interpreted as supportive of the local currency pricing hypothesis. Changes in the exchange rate have however, substantial effects on the consumer price index inflation even in the short run.

2.4 The article by Benedictow and Boug (2012)

The background for Benedictow and Boug (2012)'s study are several studies that find evidence of incomplete exchange rate pass-through, which is often explained by pricing-to-market behaviour under conditions of imperfect competition and segmented markets, see Menon (1995a), Goldberg and Knetter (1997), Gil-Pareja (2003), Herzberg et al.(2003), Campa and Goldberg (2005), Atkeson and Burstein (2008), Bugamelli and Tedeschi (2008), Thomas and Marquez (2009) and Gust et al. (2010). Also, empirical studies of small open economies show that import prices do not fully respond to changes in exchange rates and that domestic market conditions influence the price setting behaviour of foreign firms, see Menon (1995b), Menon (1996), Naug and Nymoen (1996), Alexius (1997), Kenny and McGettingan (1998) and Doyle (2004). They are motivated by the observed low consumer price inflation over several years, which they think coincides well with the simultaneous fall in import prices on clothing. Benedictow and Boug (2012) handle the issue of pricing-to-market by ways of controlling for potential pass-through effects of the gradual removal of non-tariff barriers to trade, such as the removal of quota regulations in 1995-2005 and the reduction in tariff rates over time, and the switch in imports from

high- to low-cost countries.

Because economic theory predicts that the presence of non-tariff barriers to trade is potentially important when quantifying the degree of pass-through to traded goods prices, it is crucial when estimating the degree of pass-through that, effects of the removal of non-tariff barriers to trade are accounted for. This is the Bhagwati hypothesis, which says that the presence of non-tariff barriers to trade may affect pass-through. A small currency depreciation in the presence of non-tariff barriers to trade will generally reduce the quota rents first, thereby absorbing much of its impact, before it is reflected in the market price. If, on the other hand, the depreciation is so large that it pushes the market price above the point where the quota restrictions are no longer binding that pass-through will be positive, but incomplete according to the Bhagwati hypothesis. Since previous studies usually ignore this hypothesis, it is a question that Benedictow and Boug (2012) try to answer by focusing on the link between non-tariff barriers to trade and pass-through.

The trade liberalisation in the 1980s and 1990sled to a shift in the number of exporting partners, and many countries switched their imports from high cost countries to low cost countries, a phenomenon known as the China effect. Benedictow and Boug (2012) control for non-tariff barriers to trade and the switch from high- to low-cost countries by applying the Törnqvist and the Fisher price index formulas (explained below). A third index number formula is used, the geometric mean price index with constant import shares, but this index measurement fails to account for the China effect. Benedictow and Boug (2012) use quarterly and seasonally unadjusted data for the period 1986-2008 in a cointegrated vector autoregressive (VAR) model when quantifying the degree of exchange rate pass-through. Irrespective of using the Törnqvist or the Fisher price index measure of foreign prices, they obtain stable and significant estimates of the exchange rate pass-through and the rate of pricing-to-market, which are estimated to be 0,44 and 0,56 respectively. When using a third measure of foreign export prices, the geometric mean price index with constant weights, Benedictow and Boug (2012) find that the estimates on these two variables are biased because this measure of foreign export prices overestimates international price impulses. Hence, Benedictow and Boug (2012) claim that the choice of aggregation formula for foreign prices matters for the quantification of an import price model. This is an issue that they believe is typically ignored in the pricing-to-market literature.

Another result they obtain is that the China effect on traded goods prices is substantial in the clothing industry. They estimate that the shift in imports from high- to low-cost countries since the early 1990s has led to an average reduction of about 2 percentage points in the international price impulses on clothing. Their findings contradict the Bhagwati hypothesis, i.e. the gradual removal of non-tariff barriers to trade pushes pass-through rates upwards, other things being equal.

3 The Theoretical Model

In this section I will develop the two testable hypothesis more econometrically. The theoretical framework behind the assumption of perfect competition in this thesis is presented and will show the modelling of import prices of vehicles.

3.1 Theoretical Framework

The market for automobiles is characterized by perfect competition between firms producing almost identical products even though this market can be segmented according to geographical, demographical, psychological beneficial and behavioural factors of the consumers. Fisher (2010) provides an overview of papers that take different approaches than that of perfect competition when analysing the market for automobiles. The producers can segment their market by the size of the car, price and pollution per kilometer. However, according to Krugman (1987), if there is no domestic competition then there should be complete pass through from an increase or decrease in the exchange rate or in the marginal costs of the exporter. If so the export market for motor vehicles in Norway is perfectly competitive and the law of one price should prevail, the following holds:

$$PB_i = E_i PX_i = E_i C^* \tag{1}$$

Equation (1) says that the import price of cars in Norwegian Kroner is equal to the export price in the currency of say, the EURO, given the bilateral exchange rates. In (2), PB_i denotes the import price of cars in Norwegian Kroner, PX_i the export price in foreign currencies, and E_i the bilateral exchange rates between Norway and its trading partners. The import price equation in Naug and Nymoen (1996) emerges by converting the equation for profit maximisation under imperfect competition to the currency of the importer,

$$PB_i = E_i PX_i = E_i \times \theta_i C^* \tag{2}$$

where PB_i denotes the import price in the importing country's currency, the second term of the equation denotes the tradeable product price in the exporting country's currency and E_i is the exchange rate between these countries. The last term is the profit on the traded product in the importing country's currency with θ_i and C^* denoting the destination specific mark-ups and the marginal costs, respectively. Destination specific mark-ups means that every country that exports to Norway sets their own prices on the products depending on the domestic market conditions in Norway. If destination specific mark ups are present, there is not perfect competition in the markets for automobiles. The destination specific mark ups are assumed to be a function of the price of the competing goods produced in the importing country, PH_i and the demand

pressure in the importing country DP_i.

$$\theta_i = K_i \left[\frac{PH_i}{PB_i} \right]^{\tau_{1i}} DP_i^{\tau_{2i}} \tag{3}$$

With the mark-ups as presented in equation (3), the import price equation (2) in the importing country's currency takes the following form:

$$pb_i = k_i + (1-\phi_i)c^* + (1-\phi_i)e_i + \phi_i ph_i - \varphi_i dp_i + \varepsilon_t \tag{4}$$

The lower case letters here denote the logarithmically transformed variables with $k_i = lnK_i/(1+\tau_{1i})$, $\phi_i = \tau_{1i}/(1+\tau_{1i})$, and $\varphi_i = \tau_{2i}/(1+\tau_{1i})$. And dp_i denotes the domestic pressure, ph_i is the domestic price of the competitive product, er_i is the exchange rates, c^* is the marginal production costs and $(1-\phi_i)$ is the measure of the degree of pass through from a change in the exchange rates and marginal production costs to prices of import. Given the levels of ph_i and dp_i, as long as there is competing product prices in the importing country, $ph_i > 0$, changes in the marginal costs and the exchange rate are not fully passed through to the import prices, $\phi_i > 0$. When $\phi_i > 0$ we have the phenomenon that is called pricing to market as defined in Krugman (1987).

3.2 Modelling the Import Price of Vehicles

The baseline model in this thesis is given by the model equation in Benedictow and Boug (2012), which again is based on the import price equation (4) from Naug and Nymoen (1996). Assuming that the vehicle export producers take prices between one another as given, a non-existing market for vehicles in Norway will lead to zero competition faced by these exporters. The pricing to market in Krugman (1987) is therefore a priori irrelevant. Because there is no domestic car production in Norway, ϕ in (4) is zero and it is reasonable to argue that the market for cars in Norway is perfectly competitive. According to (4) with $\phi = 0$, the import price equation for vehicles becomes,

$$pb_i = k_i + (1-0)c^* + (1-0)e_i + 0ph_i - \varphi_i dp_i = k_i + c^* + e_i - \varphi_i dp_i \tag{5}$$

where the same interpretation to the variables applies as previously. The exchange rates are easy to collect in reality, but marginal production costs and domestic pressure are both theoretical variables. Hence, I need to find their subsequent proxies. Like Benedictow and Boug (2012), I use the export price as a proxy for marginal production cost and the unemployment rate for domestic pressure. The series for foreign prices is normalised in Norwegian currency and is an import weighted index containing implicit deflator for car exports from seven major exporting countries accounting for Norwegian imports of cars. The exchange rate index is constructed

using the same set of weights. How these two series are constructed will be explained in the next section. Statistics of currency exchange rates are available from Statistics Norway. With the proxies for domestic pressure and marginal production cost equation (5) can be rewritten as,

$$Ipricenok_t = const + \alpha(Tforeignpricenok_t + er_t) + \varphi urnor_t + \varepsilon_t \tag{6}$$

where $Ipricenok_t$ denotes the import price in Norwegian Kroner at time t, $Tforeignprice_t$ is the Törnqvist foreign export price in foreign currencies and er_t is the import weighted nominal exchange rate index. The parameter α will be described below.

From equation (6), I am going to developed an autoregressive distributed lag model, from now on ADL, with four lags for the dependent and independent variables to test my hypotheses. The ADL model can be re-written as a dynamic cointegrated equilibrium correction model given that there is co-integration between the variables. The equilibrium correction model has the following log form in my context:

$$\begin{aligned} \Delta Ipricenok_t &= const + \alpha_{1,i}\sum_{i=1}^{4}\Delta Ipricenok_{t-i} + \alpha_{2,i}\sum_{i=0}^{4}\Delta Tforeignpricenok_{t-i} \\ &+ \alpha_{3,i}\sum_{i=0}^{4}\Delta urnor_{t-i} + \beta Eqcm_{t-1} + \theta_1 S1_t + \theta_2 S2_t + \theta_3 S3_t + \varepsilon_t \end{aligned} \tag{7}$$

where we have first difference of the import price in Norwegian Kroner, $\Delta Ipricenok_t$, the Törnqvist foreign price in Norwegian Kroner, $\Delta Tforeignpricenok_t$ and the unemployment rate, $\Delta urnor_t$ lagged four times. because we have four quarters in a year [2]. $Eqcm_{t-1} = Ipricenok_{t-1} - Tforeignpricenok_{t-1}$ is the equilibrium correction mechanism. $S1_t, S2_t, S3_t$ are the three seasonal dummies that are created to pick up the seasonally effects and to correct the effects of the constant term, and ε_t is the error term assumed to be white noise. The seasonal dummies are created such that $S1_t = 1$, while $S2_t = S3_t = 0$ in quarter one in any year. In quarter two we have $S2_t = 1$ while $S1_t = S3_t = 0$. Quarter three has $S3_t = 1$, while $S1_t = S2_t = 0$.

3.3 Developing the Hypotheses

Hypothesis 1: Perfect Competition

The null of the first hypothesis is that there is no pricing to market behaviour by the exporters, at least in the long run. That is, the ϕ in equation (4) is zero, which implies that changes in the exchange rates or in the marginal production costs are fully passed through to the import prices.

[2]Note that $Tforeignpricenok_t = Tforeignprice_t + er_t$ from (6)

Since there is no domestic competition, φ in (4) is zero. If I accept the null hypothesis of zero ϕ and φ is zero for all *i*, I do have fulfilled the assumptions of the relative version of the law of one price. If $\phi = 0$, $alpha$ must equal one. In terms of (7), no pricing to market implies that the estimated coefficient for $Eqcm_{t-1}$ is significant. If this is true, a conclusion of perfect competition can be drawn. In order for the β in (7) to be significant there must exist a long term equilibrium relationship between the import price and the export price. That the β is significant implies that cointegration exists between the import price and the export price of vehicles. The equilibrium correction term in an ECM model such as the one in (7) is integrated of order zero, I(0), only if there is cointegration between the variables, and cointegration between two variables only exist if the the error term of these two non-stationary variables, variables with unit root of order one, I(1), is of I(0). That variables are integrated of order one, I(1), means that we have to difference them once to induce stationarity. When there is stationarity in the variables, we say that they are integrated of order zero, I(0). If there is evidence of cointegration between two variables, there is a long run equilibrium relationship between them [1].

We check for stationarity by plotting the variables before and after differencing them once and we perform the augmented Dickey Fuller test. The augmented Dickey Fuller test is based on a random walk and the fact that the random walk has a unit root. If the variable in question follows a random walk, it cannot be stationary. Testing for stationarity is therefore equivalent to testing for a unit root. Assumption of the test is that the error terms follow the Gauss-Markov assumptions of normality, homoskedasticity, zero autocorrelation and so on.

Below are the plots and the augmented Dickey Fuller tests for the import price, the Törnqvist foreign export prices in Norwegian currency, the unemployment rate and the equilibrium correction mechanism, in their log form before and after differencing them one time [3].

[3]The plots and the augmented Dickey Fuller tests in the below Figures and Tables are obtained using the the econometric program STATA version 12.

Figure 2: Testing for stationarity in the equilibrium correction term

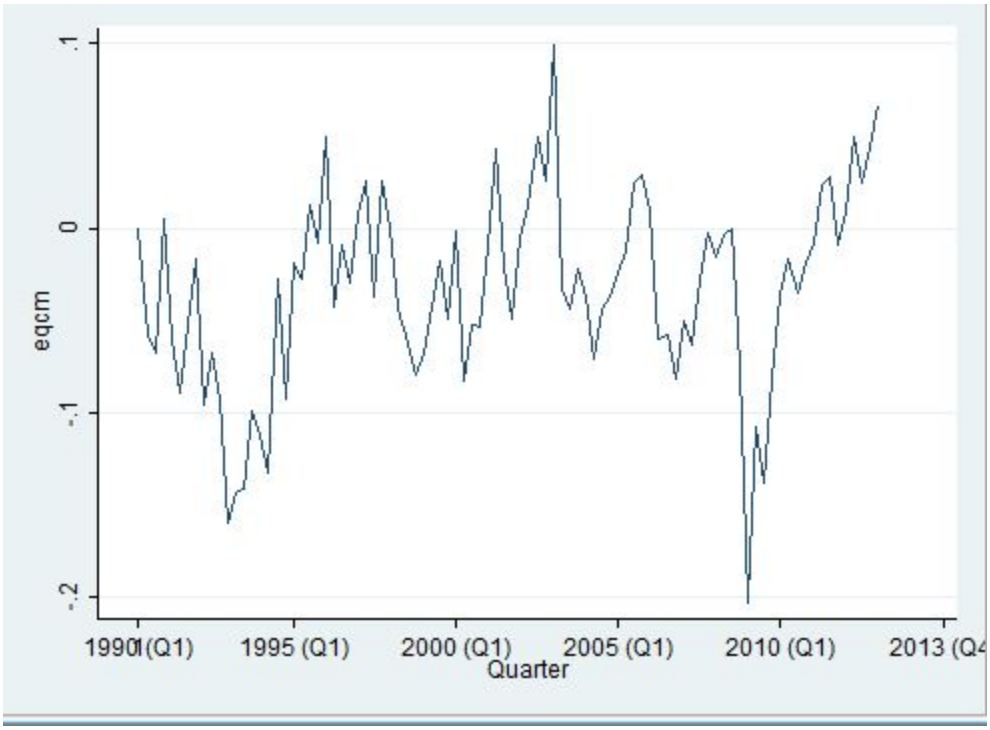


Table 1: Augmented Dickey Fuller Tests for Stationarity

eqcm: ADF tests (T=87, Constant+Trend; 5 %=-3.46 1%=-4.07)

D-lag	t-adf	Sigma	t-prob	AIC
3	−3.348	0.040	0.423	−6.324
2	−3.295	0.040	0.458	−6.339
1	−3.254	0.040	0.126	−6.355
0	−4.374**	0.041		−6.350

$^{\star}p < 0.05$, $^{\star\star}p < 0.01$, $^{\star\star\star}p < 0.001$

In Oxmetrics, Descriptive Unit Root testing has been used

Figure 3: Testing for stationarity in the Import Prices in NOK

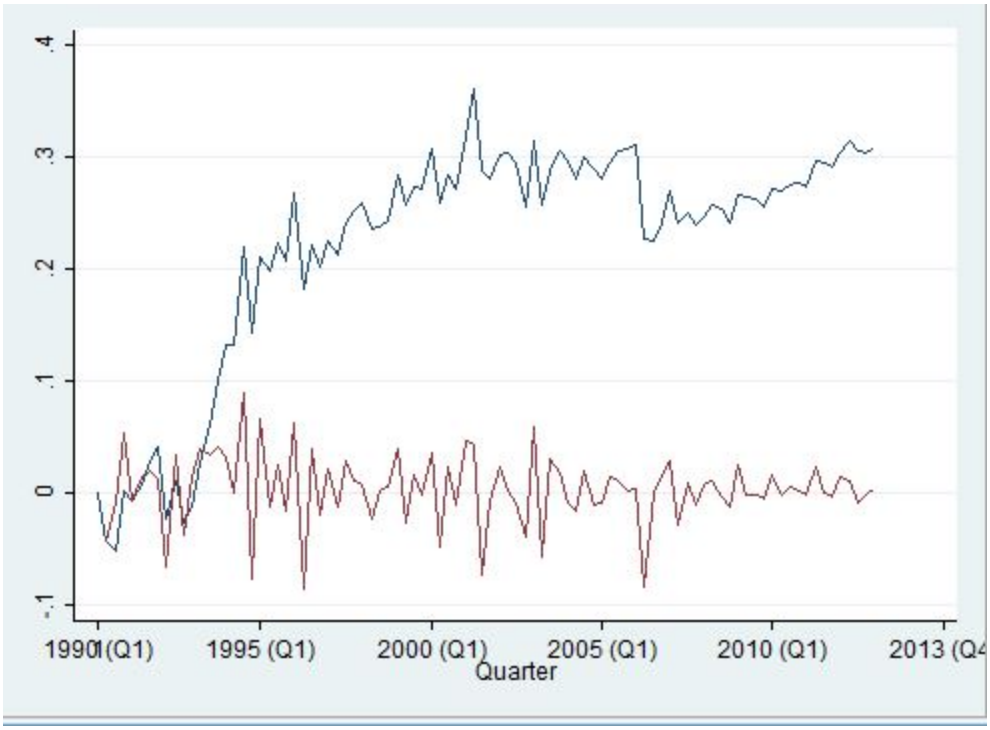


Table 2: Augmented Dickey Fuller Tests for Stationarity

$Ipricenok$, $\Delta Ipricenok$ [in brackets]: ADF tests
(T=87, Constant+Trend; 5 %=-3.46 1%=-4.07)

D-lag	t-adf	Sigma	t-prob	AIC
3	$-1,976$	0.027	0.259	-7.122
	$[-4.932^{**}]$	[0.028]	[0.378]	$[-7.084]$
2	$-2,031$	0.027	0.995	-7.129
	$[-6.826^{**}]$	[0.027]	[0.228]	$[-7.098]$
1	$-2,046$	0.027	0.000	-7.152
	$[-7.971^{**}]$	[0.028]	[0.909]	$[-7.103]$
0	$-2,767$	0.030		-6.948
	$[-15.53^{**}]$	[0.027]		$[-7.126]$

$^{\star}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

In Oxmetrics, Descriptive Unit Root testing has been used

Figure 4: Testing for stationarity of the Törnqvist Foreign Prices in NOK

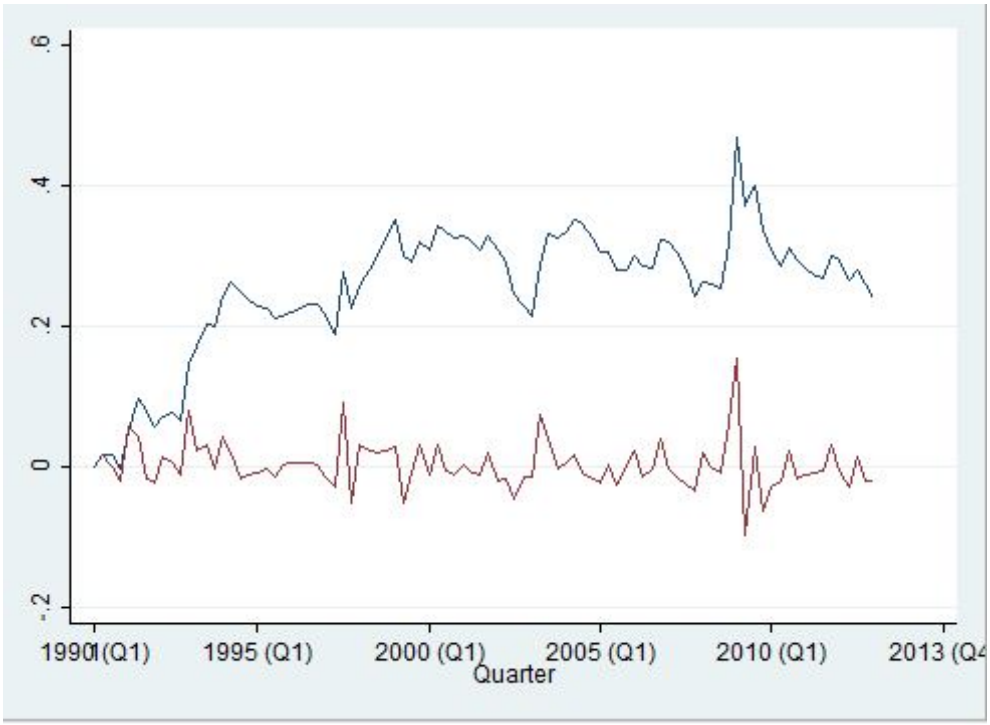


Table 3: Augmented Dickey Fuller Tests for Stationarity

$Tforeignpricenok$, $\Delta Tforeignpricenok$ [in brackets]: ADF tests

(T=87, Constant+Trend; 5 %=-3.46 1%=-4.07)

D-lag	t-adf	Sigma	t-prob	AIC
3	-2.601	0.032	0.924	-6.757
	$[-5.388^{**}]$	[0.034]	[0.351]	$[-6.687]$
2	-2.663	0.032	0.735	-6.780
	$[-5.813^{**}]$	[0.034]	[0.630]	$[-6.700]$
1	-2.663	0.032	0.571	-6.801
	$[-6.990^{**}]$	[0.033]	[0.845]	$[-6.720]$
0	-2.868	0.032		-6.820
	$[-10.47^{**}]$	[0.033]		$[-6.742]$

$^{\star}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

In Oxmetrics, Descriptive Unit Root testing has been used.

Figure 5: Testing for stationarity in the unemployment rate

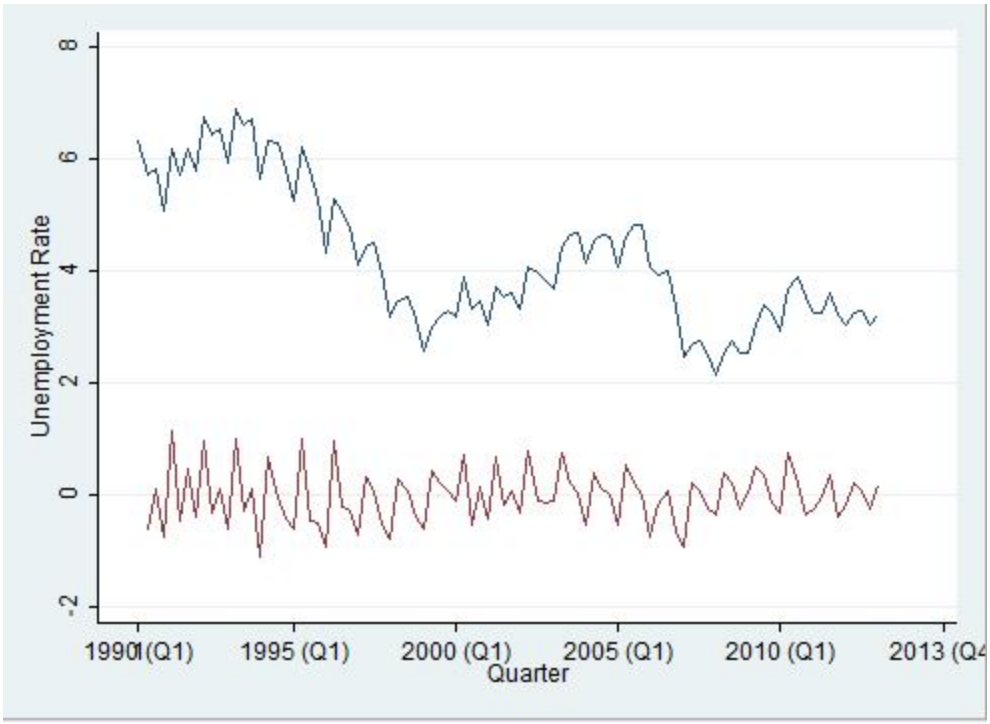


Table 4: Augmented Dickey Fuller Tests for Stationarity

urnor, Δ*urnor* [in brackets]: ADF tests
(T=87, Constant+Trend; 5%=-3.46 1%=-4.07)

D-lag	t-adf	Sigma	t-prob	AIC
3	−1.025	0.412	0.000	−1.705
	[−2.553]	[0.280]	[0.000]	[−2.476]
2	−1.725	0.446	0.322	−1.558
	[−9.762**]	[0.412]	[0.000]	[−1.715]
1	−2.011	0.446	0.034	−1.569
	[−8.663**]	[0.451]	[0.160]	[−1.545]
0	−2.700	0.455		−1.538
	[−12.73**]	[0.454]		[−1.544]

$^{*}p < 0.05$, $^{**}p < 0.01$, $^{***}p < 0.001$

In Oxmetrics, Descriptive Unit Root testing has been used.

We know that if the variables are non-stationary they can become stationary after differencing. The graphs show how each of the variables changes in terms of stationarity. We see that the figures in (2)-(5) are stationary in that all seem to be mean reverting with no particular trending behaviour. It adds as an evidence that the first differenced variables, $\Delta Ipricenok_t$, $\Delta Tforeignpricenok_t$ and $\Delta urnor_t$ are I(0), making perhaps the $Eqcm_t$ also I(0). The figure for the unemployment rate shows a downward sloping trend over time and differencing it give us

a steady movement varying between -1,1 to 1,1. Although the unemployment rate is stationary by definition, it may not be so in our sample period. The augmented Dickey Fuller tests for stationarity of import price, export price and unemployment rate are shown in the tables below their respective plots. Prior to differencing, the three tested variables all have a unit root I(1), meaning that they are non-stationary at the 5 percent confidence level. After differencing all three once, the ADF tests become significant at the 5% and in some cases also at the 1% significance level. This is not so surprising because we know that when differencing a variable that has a unit root, I(1), it becomes stationary, I(0). Based on the ADF tests, I conclude that all the variables used in the econometric modelling are non-stationary in levels and stationary in first differences. Also, the $Eqcm$ term seems to be stationary, as indicated by a significant ADF test. Hence, I may conclude that the first hypothesis of perfect competition in the Norwegian market for vehicles is not rejected. This will be pursued further in Section 6

Hypothesis 2: Zero Change in the Pricing Behaviour after the Financial Crisis

If the financial crisis has had an impact on the Norwegian economy, I would assume that the unemployment rate in Norway has increased so that the overall demand decreases. Since import of vehicles account for almost one third of the total imports of non-competitive goods and services, it is reasonable to argue that demand for vehicles will decrease. Once the decline in demand is noticeable to the exporters, we should see some changes in the pricing behaviour, at least from Germany, regardless of whether or not the producers in Germany follow a pricing to market strategy or a price-taking behaviour. If Norway's economy is not affected significantly by the crisis I would expect little or zero changes in the pricing behaviour after the crisis.

The null of the second hypothesis is that the pricing behaviour has not changed after the financial crisis in late of the third quarter of 2008. This can be tested by estimating two regressions, one for the full sample period and one for the period up to and including quarter three of 2008 and by means of a dynamic forecasting exercise. If the regression results for the two sample periods have not changed significantly, then we can confidently say that the financial crisis has not deterred the pricing behaviour of the exporters.

4 The Data

In this thesis , I examine the aggregate data for Norway [4]. As in the paper of Benedictow and Boug (2012), I use data on Norwegian unemployment rate, denoted $urnor_t$, import weighted currency exchange rates, er_{it} and the Törnqvist price index measure of foreign export prices in Norwegian currency, $Tforeignpricenok_t$. Fortunately, I have been supplied with most of the

[4] See the appendix for details of data definitions and sources

data from Statistics Norway, such as data on time series of import prices and on the Norwegian unemployment rate. The time series of import shares by country is provided by the foreign trade statistics at Statistics Norway by Øyvind Hagen. In Boug et al. (2005), data on foreign export prices was provided by the Organisation for Economic Co-operation and Development, hereafter OECD. However, after 2003 OECD no longer provides the same service to Statistics Norway. This explains why the sample period in Boug et al. (2005) ends in quarter four of 2003. Since I have almost ten years of additional data that can be extended onto their regression analyses, 36 additional observations [5], it can add to produce more efficient econometric results. Many studies have discussed and shown that the use of different price indices give different, and sometimes significantly different results, among them Feenstra (1994), Broda and Weinstein (2006) and Gaulier et al.(2008). When choosing an appropriate type of price index measures of foreign prices, I choose the price index measure that I find to be most relevant to this empirical analysis. There are several different price index number formulas that can be used in the calculation of price indices, and the use of different index formula can have significant effects on the regression results. Choosing the correct price index formula is very important for obtaining credible results, providing that everything else holds as specified.

In order to construct the Törnqvist price index measure of foreign export prices in foreign currency, I need data on import shares and export prices of the exporting countries. Since I already have time series data on import shares, I only need to create an export price index for each of the exporting countries. From the data I have received on country import shares, there are 45 countries that have had some share of the imports on vehicles to Norway recorded from the first quarter in 1988 to the fourth quarter in 2012. Many of whom had very small shares, some as little as 0.06 percent. Not only was the statistics of import shares very small, but data on the import shares were missing for several periods for many countries. Another issue is the data relevance. These are the reasons why I end up with seven countries, which are Germany, France, Japan, Sweden, the US, United Kingdom and Belgium which together account around 90 percent of the total imports of vehicles for the period 1990-2012.

[5]Most of the data I use to estimate the models have been provided to me by Pål Boug and Øyvind Hagen. One quarter is here referred to as one time period, quarter one 2004 up to quarter four 2012 gives 36 additional quarters, thereby the 36 additional time periods.

Figure 6: Imports of motor vehicles from main trading partners

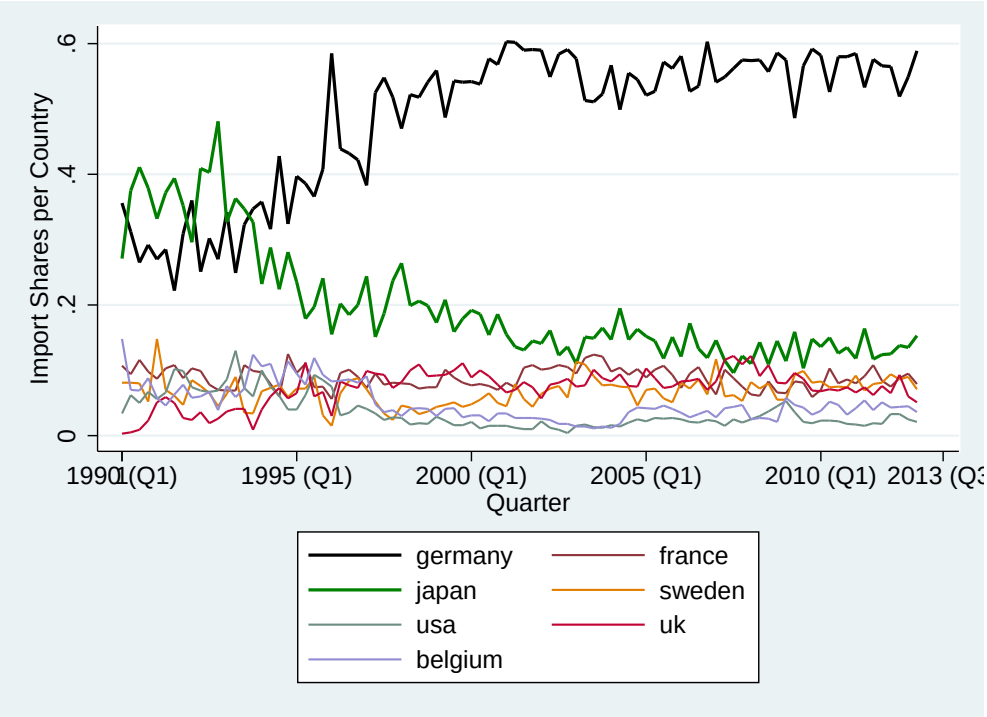


Figure 6 illustrates the development in car imports from Germany, France, Japan, Sweden, USA, UK, and Belgium for the first quarter in 1990 to the fourth quarter in 2012. From the figure, we see that Germany has had a dominating and steady rise in the share of vehicle imports. The rise in the German's car import happens simultaneously with the fall in Japan's car import. The other five countries seem to have a steady share of import throughout the period.

4.1 Brief Overview of the Price Index Number Formulas

Among the most commonly used indices are Laspeyres and Paasche price indices, and the superlative price indices. Superlative price indices treat prices and quantities equally across all periods. Of the existing superlative price indices, the Törnqvist and Fisher price index are generally the most preferred. Though Laspeyres and Paasche indices are popular, there are several problems that arise when using them. For the purpose of this thesis, using either of these indices will not account properly for the inflation effects and price level differences across countries, which is often dubbed the China effect. Another problem is that they both produce biased measures of price evolution as weights are from a single period. Hence, they fail to capture substitution effects among different goods from one period to another. The Laspeyres price index tends to overestimate price growth because it uses the weights from the base period, whereas the Paasche price index tends to underestimate price growth since it assigns larger weights to products with increased quantity following a relative price decrease. Another problem with both these indices is that they also fail to capture the disappearance of old or the appearance

of new products between the base and the comparison period. Feenstra (1994) and Broda and Weinstein (2006) conclude that the ignorance of new products generally leads to overestimation of price growth.

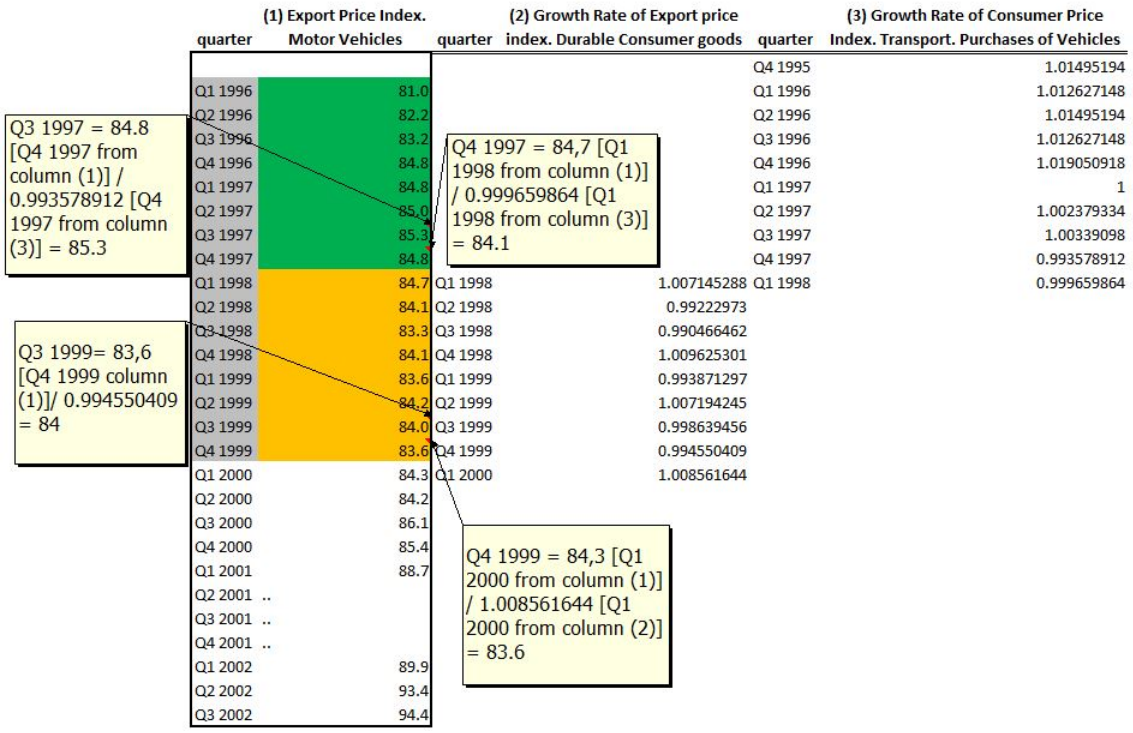
The bias in the Lapseyres and Paasche indices can be solved by replacing it with the superlative price indices. These indices are symmetrical and provide close approximations of cost of living indices and other theoretical indices used to provide guidelines for constructing price indices. All superlative indices produce similar results and are generally the preferred formulas for calculating price indices. These are indices that can solve the aggregation problem in my context. The main difference between the Törnqvist and the Fisher price index is that the former is a geometric mean of the geometric Laspeyres and Paasche price indices, while the latter is a geometric mean of the arithmetic Laspeyres and Paasche.

4.2 Merging of Foreign Export Price Time Series

Theoretically, marginal costs is the variable I should be using in this empirical study. Unfortunately, it is not possible to find data for this specific theoretical variable. Optimally, export price indices should be used because in theory, if the market is perfectly competitive, consumer prices are equal to marginal production costs and export prices reflect consumer prices. There are no time series data of export price indices that cover a period long enough for all seven countries. One way to overcome the data scarcity is to create new time series data indices for each of the seven countries, by utilising all the relevant data series indices and combine them into one series using a merging technique.

The creation of new foreign export price indices for all seven countries starts with a 'collection after criteria' process, then merging together the data series that are relevant for measuring the theoretical variable producer marginal costs before the Törnqvist price index can be developed. This means collecting data that are as close to measuring the theoretical variable as possible. In my case, producer prices of motor vehicles are more preferred than export prices of motor vehicles, export prices of motor vehicles are more preferred than export prices of durable consumer goods, which again is more preferred than export prices of manufacturing, that is more preferred than the consumer price index and so on. For illustrating how the merging technique works I have added Table 5 on the following page to make the understanding of it easier. The merging of different time series data works as follow.

Table 5: Merging of Time Series Data

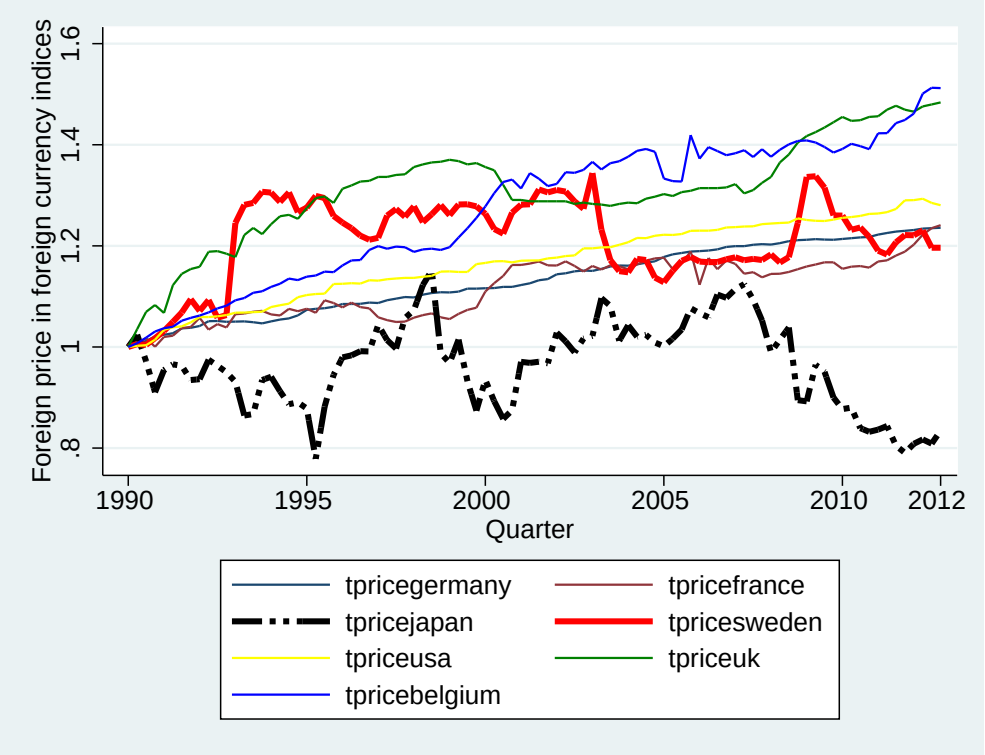


In Table 5 I have included some random numbers and random types of time series data. The table shows three time series data indices, the export price of motor vehicles indices in column (1), the export price of durable consumer goods index in column (2) and the consumer price index of transport purchases in column (3). The series in column (1)-(3) all end at the same point, that is, they all end in quarter three 2002. For simplicity and to save space, I only illustrate from when the three series begin. Here the series in column (1) is more preferred than the series in column (2), which again is more preferred than the series in column (3) because of how well they measure producer marginal costs. To merge these three series I am going to extending the export price index on motor vehicle series in column (1) back to 1996, where the series (3) begins. The measure for the fourth quarter in 1999 in the export price index on motor vehicles, column (1), can be obtained by taking the value from the first quarter in 2000 in that series and divide by the growth rate of quarter one 2000 and quarter four 1999 in the next preferred series, the export price index series for durable consumer goods. This is highlighted by the box in the lower right corner. Quarter three 1999 measure for the export price index of motor vehicles is then the result we have obtained for quarter four 1999, divide by the growth rate of quarter four and quarter three 1999 from column (2) series. This is highlighted by the box in the lower left corner. The process goes on until I get to the beginning of the series in column (2), that is, when I get to quarter one 1998. Merging the series in column (3) to the now extended series in column (1) follows the exact same recipe. The arrow in the upper left and right corners explain the merging of column (1) series and column (3) series. I continue this process for all seven countries and end up with seven single time series data of foreign export price, some merged

with one other data series or more.

Finally, after I have obtained seven new data series on foreign export price in foreign currency, I convert them to relative price indices by choosing any random base quarter. I have chosen to have quarter one 1990 as base quarter because it is easier to see how these series vary when they all have the same value starting from the origin.

Figure 7: Merged Time Series of Foreign Price in Foreign Currency Index



The above figure shows the final series of foreign price in foreign currency indices, which are relative price indices to quarter one in 1990 after I have merged together several data series for countries United Kingdom, France, Germany and Belgium. Countries such as Sweden, the United States and Japan have good statistics that extend many years back in time. The curves for Japan and Sweden stand out as the curves with largest fluctuations together with a decreasing trend after the financial crisis in later 2008. The other five countries do have a upward sloping trend throughout the sample period.

4.3 Developing the Törnqvist Price Index

By plugging the import shares and the foreign export price indices for the seven countries directly into the Törnqvist price index measure of foreign prices I am able to capture not only inflationary impulses implied by price changes and substitution between goods with different price changes, but also varying import shares and differences in price levels. The Törnqvist

price index formulae are defined by as:

$$\frac{P_t}{P_b} = \prod_{i=1}^{I} \left(\frac{P_{i,t}}{P_{i,b}} \right)^{\bar{S}^*_{i,t}} \tag{8}$$

$$\frac{P_t}{P_{t-1}} = \prod_{i=1}^{I} \left(\frac{P_{i,t}}{P_{i,t-1}} \right)^{\bar{S}_{i,t}} \tag{9}$$

with $\bar{S}^*_{i,t} = \frac{S_{it}+S_{ib}}{2}$ and $\bar{S}_{i,t} = \frac{S_{it}+S_{i,t-1}}{2}$, where S_{it} is the import share of country i in period t with $i = Germany, France, Japan, Sweden, USA, UK, Belgium$ and b is a specific quarter chosen to be the base quarter in the years 1990-2012. The prices in the nominator and the denominator are the seven single merged time series data of foreign export prices in foreign currency. We can see that equation (8) gives results that are dependent on which quarter I choose as the base quarter. Equation (9) is a special case of equation (8) because the base quarter dependency in (8) can be removed by dividing $P_{i,t-1}$ in the denominator instead of dividing by $P_{i,p}$.

To get the chained Törnqvist price index, each time periods from the original merged export price index series are divided by one another, to get a series with continuous base quarter. The results are the new relative price levels between each of the time periods for each of the countries. Then I calculate the Törnqvist price indices according to (9).

Figure 8: Törnqvist Price Index: Chained vercus fixed base period

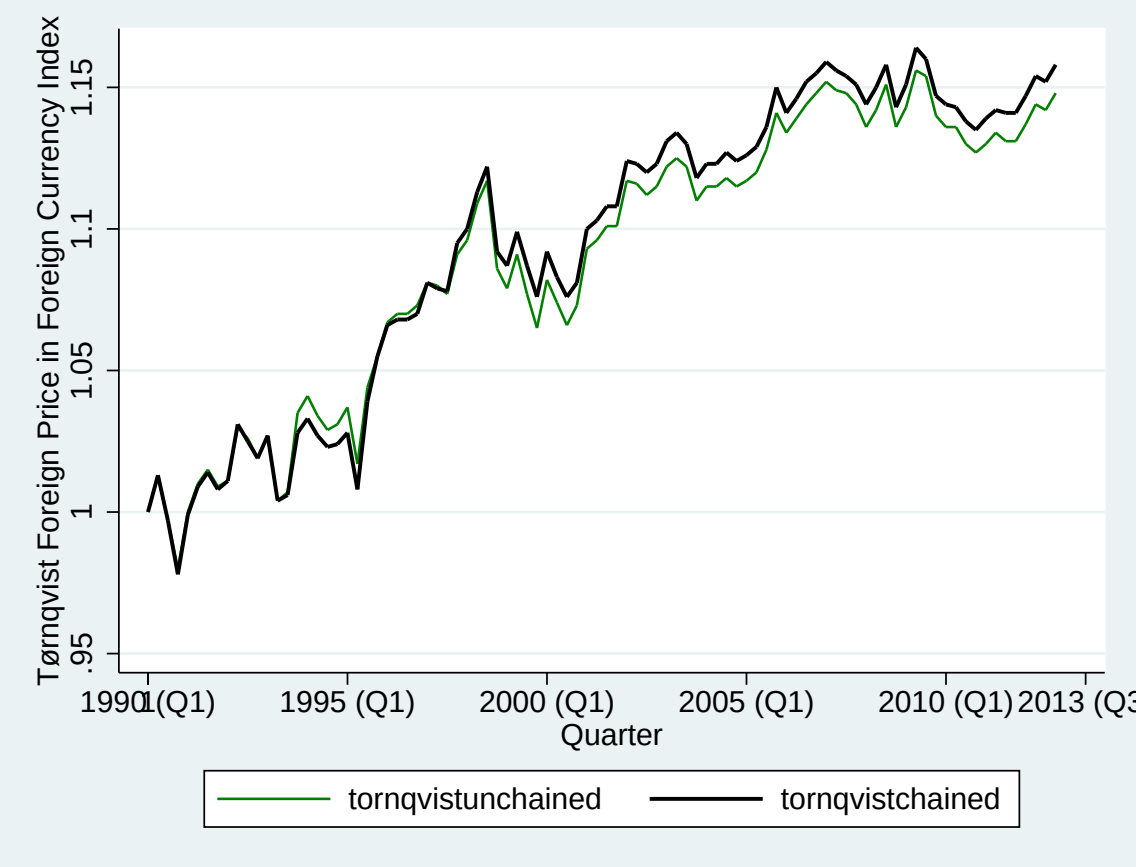


Figure 8 illustrates the difference between the outcomes in equation (8) and equation (9). The results from both equations are very similar. Both lines have the same trend and they move in the same direction. We note that the only difference is the absolute value. Before quarter one 1995 the red line lies below the blue line. Between 1995 and 1999 the two lines are almost identical, while after 1999 and throughout the period the red line dominates and lies above the blue line. [6]

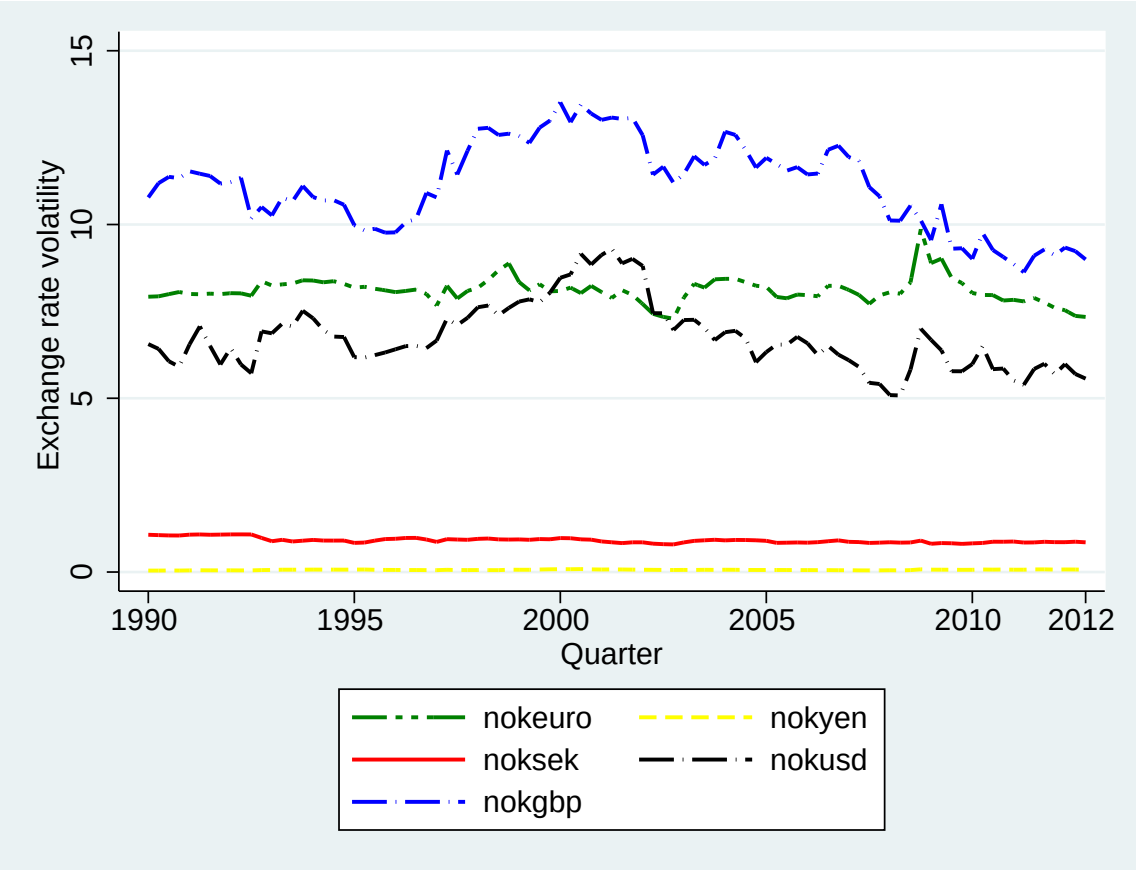
4.4 Chained import-weighted nominal exchange rate index

In order to transform the Törnqvist price index in foreign currency into Norwegian currency, an import weighted nominal exchange rate index must be developed. I apply the formula developed by the Norwegian Central Bank for currency aggregation of I-44. The nominal import weighted exchange rate index series is a chained geometric mean index and the construction of it parallels that of the Törnqvist in (9) in the sense that the bilateral exchange rates between Norway and the seven trading partners are weighted together with their respective import shares as

[6]The use of the Törnqvist from equation (8) gives almost identical results in terms of significance and economic conted of the estimated model for the import price of vehicles. For this reason, I only present econometric results using the Törnqvist price index measure of foreign prices based on equation (9) in this thesis

weights. To calculate the import weighted nominal currency exchange rate index, I need data on import shares for the seven countries and their respective currency exchange rates, NOK/SEK, NOK/YEN, NOK/EURO, NOK/USD, NOK/GBP. The NOK/EURO is the Norwegian exchange rate on the EURO and is the common currency for the countries Germany, France and Belgium, NOK/SEK is the Norwegian Swedish exchange rates, NOK/YEN is the Norwegian Japanese exchange rate, NOK/USD is the Norwegian American exchange rate and NOK/GBP is the Norwegian on UK exchange rates. Figure 9 shows the trend in the Norwegian NOK on the other seven currencies.

Figure 9: The Norwegian NOK against the EURO, YEN, SEK, USD and GBP



From Figure 9 we see great volatility of the NOK on the British Pound and the NOK on the American Dollar, while for the NOK on the YEN and the NOK on the SEK seem to be of no dramatic fluctuations throughout the whole period. The Norwegian NOK on the European EURO seems to have a very stable relationship until around 1997. After 1997, it has been more volatile, especially around the time when the financial crisis hit the Norwegian economy.

Figure 10: NOK/YEN Currency Volatility for the Period 1990-2012

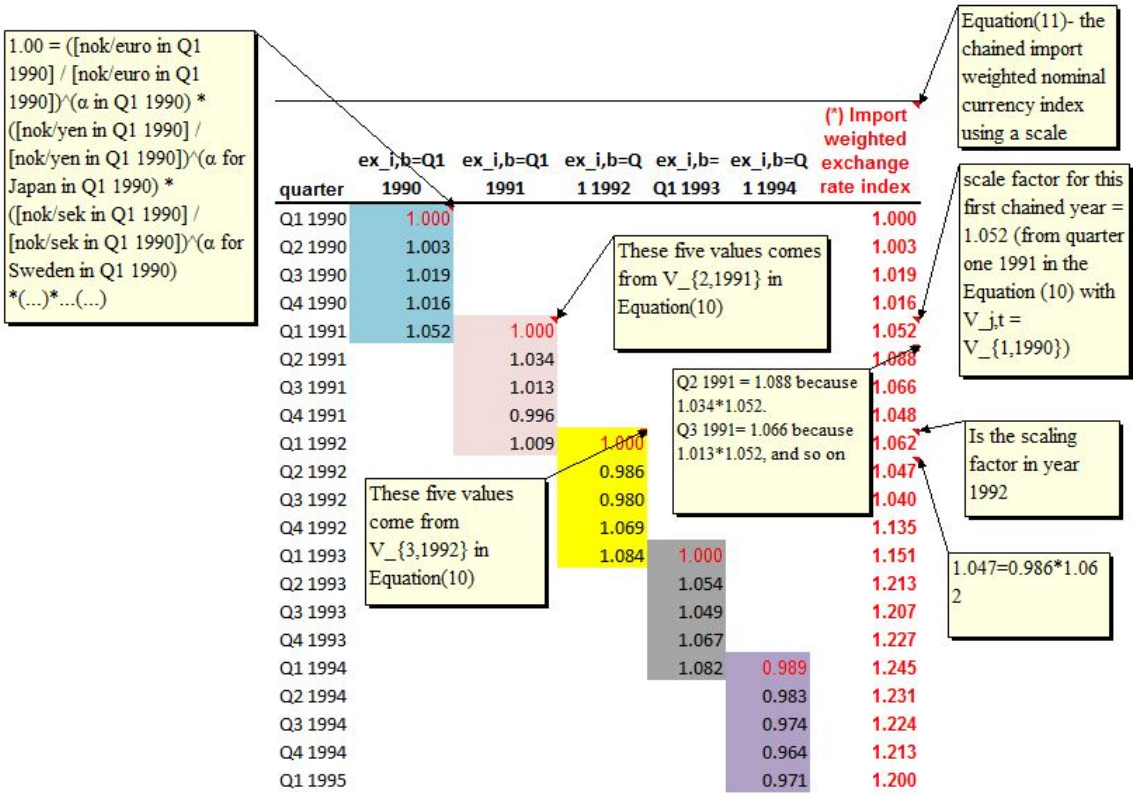
Figure 10 shows that the NOK/YEN does have great volatility throughout the period. The scale of the variation is small, hence placing it in a common figure, like that in Figure 9, may make it seem like there is almost no variations in the two currencies.

The first step to calculate the chained import weighted nominal exchange rate indices, er_t, is to calculate the per year interval import weighted nominal exchange using quarter one as base for all year intervals, $V_{j,t}$ in equation (10) below [23].

$$V_t = \prod_{i=1}^{I} \left(\frac{ex^i_{n,t}}{ex^i_{b_0,t}} \right)^{\alpha^i_{b_0,t}} \tag{10}$$

with $i = NOK/EURO, NOK/SEK, NOK/USD, NOK/GBP, NOK/YEN$, $n = q1, q2, q3, q4$, α is the import shares for each country i and b is the chosen base quarter for each year. For the years 1990-2012 we should obtain $V_t = V_{1990}, V_{1991}, V_{1992}.....V_{2012} = 23$ single year interval with five quarters in each year and one overlapping quarter. Once the 23 year intervals have been calculated, I perform the chaining of these year intervals. Figure 11 on the following page shows how the chaining is constructed.

Figure 11: Calculation of Chained Import Weighted Nominal Exchange Rate Index



The small boxes highlighted with colors represent the year intervals from equation (10). In the last column, highlighted in red, are the final chained import weighted nominal exchange rate indices, that emerge when I interconnect the year intervals with a scaling factor equal to the last period in the first year interval. This scaling factor is then multiplied with the quarters in the next year interval. Notice for example that the first five values for quarters one, two, three, four in 1990 and quarter one in 1991 in the column for $ImportWeightedExchangerateindex$ (1) are taken directly from V_1990, the box highlighted in blue. The values for Q2 1991 in column (1) is equal to quarter two of the second year interval, highlighted by the pink box, multiplied with the scaling factor=1.052. keeping the scale factor of 1.052 fixed, the same procedure applies to Q2 1991, Q3 1991, Q4 1991 and Q1 1992 in column (1). When the second year interval ends, the next scaling factor is determined by the product of Q1 1992 in the pink box and the base value in Q1 1991 in column (1). Keeping the new scaling factor of 1.062, keeping this scale factor fixed, the same procedure applies to rest of the quarters in 1992 in the chained column (1). Column (1) is the final product when the chaining process is complete. Chaining the import weighted currency exchange rate index makes the indices less independent of our choice of the base quarters as for the calculation of the Törnqvist price index measure of foreign prices.

Figure 12: Chained Import Weighted Nominal Exchange Rate Index

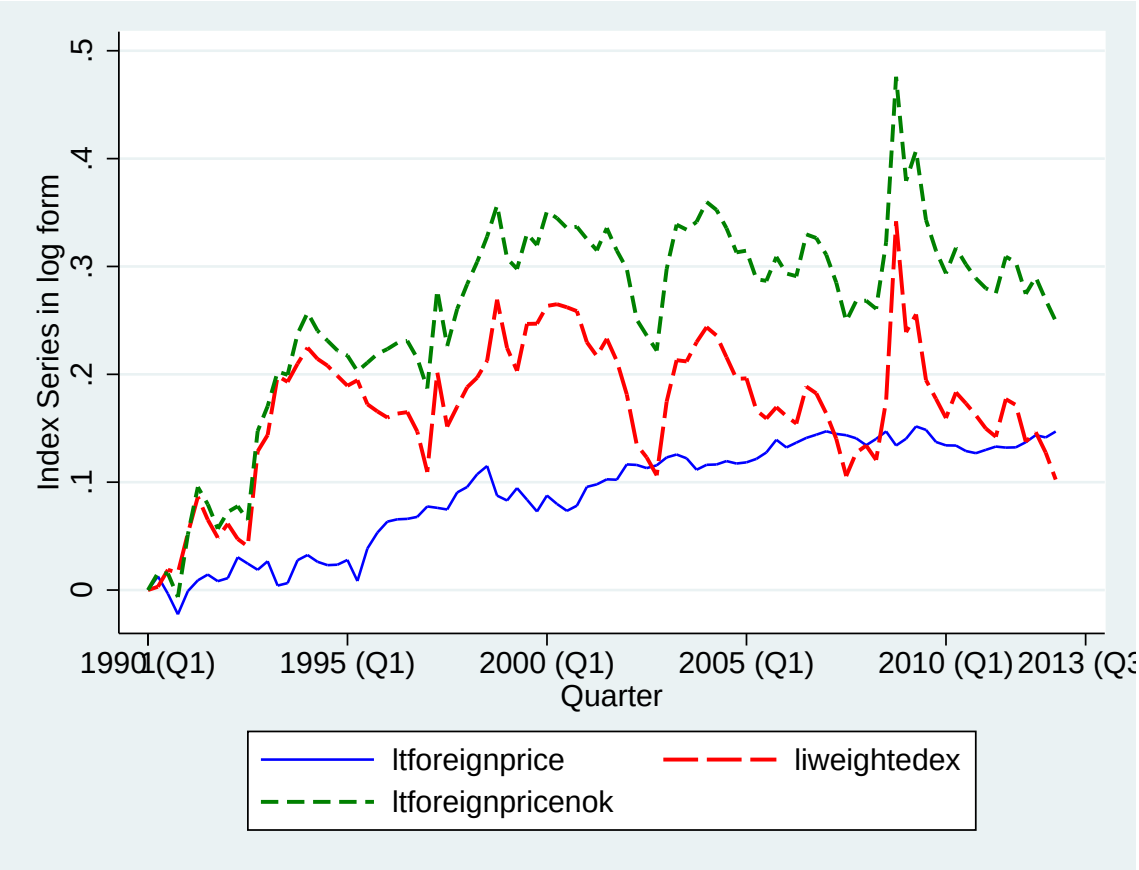


Figure 12 shows the import weighted exchange rate index, the Törnqvist price index in foreign currency and in Norwegian currency in their log form. The plot of the Törnqvist price index in foreign currency shows a steady upward sloping trend over time, cf. figure 8 on page 22. The graphs for the Törnqvist price index in Norwegian Kroner and the import weighted nominal exchange rate index seem to follow one another.

5 The Econometric Procedure/ Regression Analysis

In this section I present the results from the estimations. I will test the hypothesis that have been developed in the previous section, and last is a discussion of how the model equation in (5) can be altered using different types of variables.

5.1 Econometric Method

The equilibrium correction model in (7) can be estimated in two different ways. We can prior to estimating it, perform the two step Engle-Granger method, where the first step is to estimate the cointegration relationship and test for cointegration in the variables by testing for stationarity in the residuals. Second step, if the ADF test of the residuals is significant, the null of no

cointegration is rejected and an error correction model can be formed. Another way to start off with the estimation is to assume cointegration in the equilibrium correction term and estimate (7) without going via the Engle-Granger method. I will rely on the latter approach in this thesis. The equilibrium correction model is a representation of the short run dynamic relationship between the import price and the export price, in which the equilibrium correction term incorporates the long-run relationship between the export price and the import price of vehicles. In all equilibrium correction models, there are only I(0) variables, that is, all the variables in the ECM model is stationary. The number of lags of the explanatory variables and the dependent variables are four. The equilibrium correction term tells us the speed with which our model returns to equilibrium following an exogenous shock. It should be negatively signed, indicating a move back towards equilibrium, a positive sign indicates movement away from the equilibrium. The coefficient should be between 0 and 1, with 0 indicating no adjustment one time period later while 1 indicates full adjustment on time period later. The error correction term can be both the difference between the dependent and independent variable lagged once, or the residual from the cointegrated relationship lagged once. A highly significant estimate of the error correction term supports for a cointegration result. The ECM model can be used for dynamic forecasting of the dependent variable. In order to have the dependent variable, $Ipricenok_t$ cointegrated with the independent variables, $Tforeignpricenok_t$, the error term, ε_t in (7), must be stationary. If the error term is stationary the following assumptions must hold. The error term, u_t, is identically and independently distributed with zero mean and variance σ_u^2. If cointegration exists, the equilibrium correction term will be significant in (7).

5.2 Empirical Findings

5.2.1 Testing of Hypothesis 1

I estimate an equilibrium correction model of the import price of vehicles using quarterly, seasonally unadjusted data for the period 1990(1)-2012(4) [7] and look for cointegration in the long run equilibrium equilibrium correction term, $Eqcm_{t-1}$, which is the difference between the first lag period of import prices and export prices, $eqcm_t = logIpricenok_t - logTforeignpricenok_t$, measured in NOK.

After allowing for lags, the sample period used for estimations is 1991(2)-2012(4). I start with the general ECM model in (7) using four lags of the dependent and all independent variables, first lag of the equilibrium correction term, first lag of the long run unemployment rate and three seasonal dummies. The values of the dummies are as defined in the previous chapter [8]. All variables, except the unemployment rate, are in log form. Estimating the general dynamic

[7] All the regressions in this thesis are obtained by utilising the econometric program Ox Professional 6.30 and PcGive 13.30

[8] Naug and Nymoen (1996) use step dummies, centred seasonal dummies and impulse dummies to fit the different purpose. I did utilise the centred seasonal dummies and the results are not much different from that of the

time series model in (7) using the OLS estimation method yields,

$$\begin{aligned}
\Delta Ipricenok_t = {} & \underset{(0,01431)}{0,004097} - \underset{(0,1204)}{(0,2621)}\Delta Ipricenok_{t-1} - \underset{(0,1234)}{0,01612}\Delta Ipricenok_{t-2} \\
& + \underset{(0,1226)}{0,03227}\Delta Ipricenok_{t-3} - \underset{(0,1065)}{0,04749}\Delta Ipricenok_{t-4} + \underset{(0,01165)}{0,01052}\Delta urnor_t \\
& + \underset{(0,1065)}{0,004853}\Delta urnor_{t-1} - \underset{(0,01086)}{0,01846}\Delta urnor_{t-2} - \underset{(0,01063)}{0,006828}\Delta urnor_{t-3} \\
& - \underset{(0,01138)}{0,01087}\Delta urnor_{t-4} + \underset{(0,08359)}{0,01483}\Delta Tforeignpricenok_t \\
& + \underset{(0,1036)}{0,003076}\Delta Tforeignpricenok_{t-1} - \underset{(0,09891)}{0,09506}\Delta Tforeignpricenok_{t-2} \\
& - \underset{(0,09750)}{0,1227}\Delta Tforeignpricenok_{t-3} - \underset{(0,09407)}{0,06049}\Delta Tforeignpricenok_{t-4} \\
& - \underset{(0,08415)}{0,2690}\Delta eqcm_{t-1} + \underset{(0,002578)}{0,0029019}urnor_{t-1} - \underset{(0,01736)}{0,03364}Seasonal_t \\
& - \underset{(0,01813)}{0,03137}Seasonal_{t-1} - \underset{(0,01576)}{0,02302}Seasonal_{t-2} + u_t
\end{aligned} \tag{11}$$

with standard error in parentheses. In the regression, the standard errors are in parenthesis and the default standard error specification is applied. By using the default standard error I implicitly assume normality in the error term, that is, no autocorrelation and homoskedasticity in the variance, the standard assumptions required to have unbiased, efficient and consistent estimates. The test statistics show that only $\Delta Ipricenok_{t-1}$, $\Delta urnor_{t-2}$, $Eqcm_{t-1}$, $Seasonal_t$ and $Seasonal_{t-1}$ are statistically significant. The tests that follow from this regression on autocorrelation, homoskedasticity, residual normality and other misspecifiations indicate that we have fulfilled all the requirements of the residual in an OLS regression framework. The model can be said to satisfy the Gauss-Markov theorem and the test statistics are valid for hypothesis testing.

The fact that neither of the estimates for $Tforeignpricenok$ and *urnor* are statistically significant raise concern about this regressor and the data generating process. A simple way to check if these estimates still remain insignificant is to estimate (7) once more, only this time I use two lagged periods of *urnor* and $Eqcm$ instead of one lagged period. We notice that this is nothing, but a re-parameterization of the general model in (7) which produces the same estimated model. The results show that only the first lag of the dependent variable, $\Delta Ipricenok_{t-1}$, and $\Delta Tforeignpricenok_{t-1}$ have changed. The first lag of the dependent variable has changed in both magnitude and statistical significance. Its magnitude and test statistics are almost doubled that of (11) and $\Delta Tforeignpricenok_{t-1}$ has changed from 0.003 to 0.27 in magnitude and the test statistics now show statistical significance with a p-value = 0.002 as opposed to 0.976 in the

”normal” seasonal dummies

first regression of (11). No changes have happened to the other terms in (11). The same conclusion is drawn upon the results of the long run unemployment rate. The long run unemployment rate still remains insignificant, therefore it can be interpreted as if the foreign automobile producers do not incorporate the Norwegian unemployment rate in their long run pricing behaviour. We also see that the estimated coefficients of the equilibrium correction mechanism for both lag one and lag two period are strongly significant. What this means will be explained below.

Removing all the terms that are insignificant from the modified regression equation in (11), I am left with the following parsimonious model and its diagnostic [9] tests with standard errors in parenthesis below the point estimates,

$$\begin{aligned}\Delta Ipricenok_t = & \underset{(0,004601)}{0,007783} - \underset{(0,1034)}{0,4860}\Delta Ipricenok_{t-1} + \underset{(0,07707)}{0,2701}\Delta Tforeignpricenok_{t-1} \\ & - \underset{(0,007154)}{0,02459}\Delta urnor_{t-2} - \underset{(0,05745)}{0,2083}eqcm_{t-2} - \underset{(0,007434)}{0,02648}Seasonal_t \\ & - \underset{(0,008214)}{0,02099}Seasonal_{t-1}\end{aligned} \tag{12}$$

Method: OLS, Diagnostic Tests: T=92(1990:1-2012:4), $AR_{1-5}: F(5,77)$=0.13631 [0.9834], $ARCH_{1-4}: F(4,81)$=1.7810 [0.1407], NORM:$\chi^2(2)$=4.8853 [0.0869], $HET: F(16,72)$=1.1268 [0.3482], RESET:F(2, 80)=0.29422 [0.74.

As can be seen from the diagnostic tests, the model in (12) has no misspecification problems, no issue with the residual normality, the test for no autocorrelation is accepted and there is no sign of heteroskedaticity of the errors. The test statistics can therefore be used for hypothesis testing. Like Boug et al. (2005) I get a significant estimate of the first lag of the import price, but Boug et al. (2005) get significant estimates of the second and third lag of the import price. I get significant estimate of the first lag of the export price, $\Delta Tforeignpricenok_{t-1}$ while Boug et al. (2005) get significant estimate of the non-lag of export price, $\Delta Tforeignpricenok_t$. But, as opposed to Boug et al. (2005), the long run estimate of unemployment rate does not enter significantly in my regression. Although both Boug et al. (2005) and I get significant estimate of the equilibrium correction term, my estimate is almost twice as big as theirs.

The change in the unemployment rate lagged twice is significant in (11), which indicates that an increase in the unemployment rate lag 1 percentage point leads to a decrease of 0.025 % in the import price. The import price seems to respond to changes in the unemployment rate in the short run, even though it is only a very small effect. As opposed to Boug et al.

[9] AR_{1-5} is the Harvey (1981) test for until 5th order residual autocorrelation; $ARCH_{1-4}$ is the Engle (1982) test for until 4th order autoregressive conditional hetereroskedasticity in the residuals; NORM is the normality test outline by Doornik and Hansen (2008), HET is a test for residual heteroskedasticity according to White (1980) and $RESET$ is the Ramsey (1969) test for functional form misspecification. The numbers in square brackets are the p-values [3]

(2005) the unemployment rate does not enter the parsimonious equation in (12) in the long run relationship. Boug et al. (2005) conclude that the presence of domestic market conditions in the long run can be interpreted as evidence of pricing to market behaviour, but not in the terminology of Krugman (1987). If so, the non-existence of the long run unemployment rate in (11) add to the argument of no pricing to market in my case, at least not in the long run. A negative estimate of the first lagged dependent variable of -0.49 makes the adjustment process of import prices a lot less smooth.

The estimate of the equilibrium correction term in (11), and thereby (12), is strongly significant, with a p-value of 0.0009. This is a strong sign of cointegration between the export price and import price. Cointegration means that the export price in Norwegian Kroner and the import price tend to move together through time, perhaps because of their common underlying stochastic forces. A p-value of 0.0009 can also be used as evidence of no pricing to market in the import prices and my first hypothesis of perfect competition can be accepted. A strong coefficient of the equilibrium correction term implies complete pass through, or that ϕ in (4) is zero. An estimate of negative 0.21 suggests that there is 21 percent movement back towards the equilibrium following a shock to the model, two time periods later.

An estimate of 0.27 for the first difference of export prices, lagged once, implies incomplete pass-through in the short run. An interpretation of this estimate can be that, in the event of a shock in the exchange rates or in the marginal production costs, only 27 % of these shocks will be passed through from the export price to the import price. A magnitude of 0.21 in the equilibrium correction term, which is a moderate speed of adjustment, tells us that it will take some time before the pass-through is complete. I have now proven, with simple regression estimations, that in the long run there will be perfect competition and we will obtain law of one price in the market for motor vehicles. This implies that in the long run there is no pricing to market, indicating no divergence in the prices of imports and the prices of exports of the market for vehicles.

Hypothesis testing using the test statistics from the regression results above are valid. The regressions above are not spurious regressions because all the terms in the regression equation (12), are integrated of the same order, that is they are integrated of order zero, I(0). Because all the variables in the error correction models do no have unit root, we can conclude that the ECM models are balanced equations. Generally speaking, if the regression equations are unbalanced, or spurious, the t-values or the p-values cannot be used for hypothesis testing.

5.2.2 Testing of Hypothesis 2

Table 6 on the next page shows a comparison of estimates for the full sample period and the regression that ends in quarter three 2008 when the financial crisis first hit the Norwegian economy. The estimates on import prices and Törnqvist foreign export prices for the two regressions

do vary a little, from -0,54 to -0,48 in the regression that ends in quarter three 2008 and in the regression with full sample. The signs on these estimates are still negative suggesting that import prices from the quarter before does have a negative impact on import prices for the current quarter. The test statistics for all seven variables in both regressions are very strongly significant and the change of the magnitude of the coefficients are very small except for the changes in the coefficients for the import price, the Törnqvist foreign export prices and the equilibrium correction mechanism. We see the largest changes in the magnitude of these three coefficient estimates is on the Törnqvist lagged one period coefficient. It went from 0,40 to 0,27 in the full sample regression, an increase of 0,13 in magnitude. The changes in the coefficients for the import price and the equilibrium correction mechanism are of small magnitude, 0,06 and 0,07 respectively.

Table 6: Comparing price behaviour before and after the Financial Crisis in 2008

	(1)	(2)
Variables	OLS full sample	OLS, 1990(Q4)-2008(Q3)
$DIpricenok_{t-1}$	-0.486087	-0.542748
	(0.1034)	(0.1182)
$DTforeignpricenok_{t-1}$	0.270102	0.406726
	(0.07707)	(0.1081)
$Durnor_{t-2}$	-0.0245925	-0.0241017
	(0.007154)	(0.007922)
$eqcm_{t-2}$	-0.208304	-0.272330
	(0.05745)	(0.07635)
Constant	0.00778347	0.00610238
	(0.004601)	(0.005689)
$Seasonal_t$	-0.0264868	-0.0283763
	(0.007434)	(0.008520)
$Seasonal_{t-1}$	-0.0209976	-0.0240779
	(0.008214)	(0.009834)

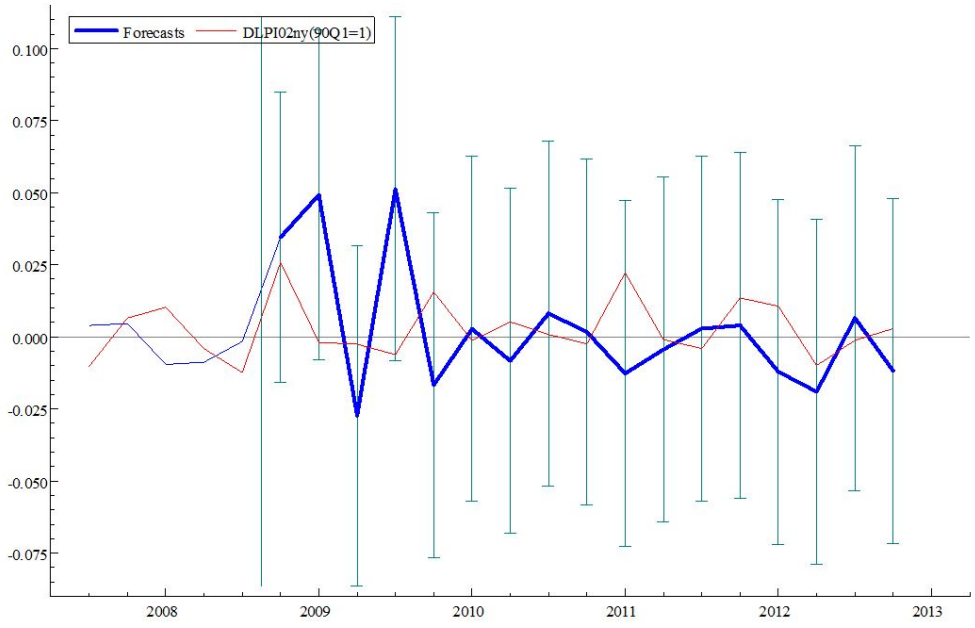
$^{\star}p < 0.05$, $^{\star\star}p < 0.01$, $^{\star\star\star}p < 0.001$ (estimated standard errors in parentheses)

In Oxmetrics I have used times series, single equation dymanic OLS estimation, no robust

Because of zero changes in the test statistics and significance of all the estimated effects in the full sample and the sample up to quarter three 2008, the following interpretation is drawn upon the results. The pricing behaviour does not appear to have changed much when the financial crisis hit the economy or the years after. One reason can be that Norway was not affected by the crisis to the extent that its demand for vehicles have not decreased in a noticeable size. If so, exporting vehicle producers do not need to alter their pricing behaviour as much when determining a price on the vehicles sold to Norway. As suggested in Figure 6, the biggest supplier of

foreign vehicles exports is Germany. Since Germany has a share of close to 60% of the import on vehicles, while the other six countries have on average around 30%, a possible change in the pricing behaviour of these six countries will be absorbed by the market power from German exporters.

Figure 13: Dynamic forecasts, 2008 (Q4)- 2012 (Q4)



As previously mentioned, I also test my second hypothesis by means of a dynamic forecasting exercise on model (12). That is, I estimate model (12) for the sample period 1990 (Q1)-2008 (Q3), leaving 17 observations for dynamic forecasting on the estimated model. Figure 13 shows the out-of-sample prediction of import prices for vehicles. Because all the 17 forecasts from 2008 (Q4)-2012 (Q4) lie inside the +/-2 confidence intervals, it show that pass through is strongly constant throughout the period of the financial crisis. I therefore conclude, once again, that the pricing behaviour of foreign exporters of vehicles to the Norwegian market has not changed significantly following the financial crisis. If pass-through has changed after the financial crisis in 2008, I would expect to see instabilities in the estimated model as indicated by poor out-of-sample forecasting stability.

5.3 Discussions

One could analyse the pricing behaviour using variables such as oil prices instead of the unemployment rate to account for the demand pressure. Oil prices are more volatile, hence we can experience higher jumps in demand when the prices vary that frequently. Oil prices are more directly linked to people's demand for vehicles because oil prices have an impact on the decision to a single person, whether or not he or she should buy a car. A household might have

to think twice on the decision to buy an additional car if they know that oil prices are very high. Even though oil prices might not have a huge impact for those who already made up their mind I believe it will have an impact for those who are considering buying one. For the producers it is also easier to follow the oil price trends rather than following the unemployment rate for each country that they export to. A rise in the oil price is easier to interpret than a rise in unemployment rate. Another reason why it is wise to consider including other variables that measure the demand pressure because as we can see from the analyses above, unemployment rate does not enter the long term rate of pass-through. I strongly believe that, even though the results show complete rate of pass-through in the long run, the domestic market conditions may have something to add to the price decreases of the exporters of vehicles to Norway.

Other variables that can be added to the import price equation above are geographical and demographical measures, the level of taxes and the per capita income. It is easy to argue that taxes, as with oil prices, have the same impact on the individual's decision on buying a car. It might not have as much effect as with oil prices, but I am quite confident when saying that tax level does have an impact on individuals decision when buying a car. From personal observations I find that most people do let them be influenced by how much taxes there are associated with owning a car in Norway. These people tell me that they often choose not to buy a car because of the tax level in Norway. Personally I feel the same. Geographical and demographical measures are also important determinants in the demand for vehicles. People who live in rural areas are often more dependent on vehicles as their mean of transportation because they need to travel farther for schooling, for work, for visiting friends and so on and so on. When there are challenges geographically the case is often that people buy more cars. If there are mountains, bad weather and so on, governments might not want to build more rail roads as this is too expensive. In such a case people will have to buy car to get around the country. And for countries that experience challenging weather conditions there will be an even higher demand for cars since rapid change in weather conditions lead to quicker destruction of the vehicles so that turnover in these countries are much higher than for countries that do not have the same weather conditions. All those reasons combined lead to higher demand for cars in countries that have these characteristics.

6 Conclusions

The purpose of this thesis is to analyse whether or not there is perfect competition for exporters of vehicles to Norway based on earlier analyses of Boug et al. (2005) and Benedictow and Boug (2012). Due to no domestic production of vehicles in Norway, the assumption that is crucial for bringing out pricing to market behaviour of the exporters in Krugman (1987) is not fulfilled. Krugman (1987) argue that the existence of a domestic production leads to imperfect competition between the producers in Norway and the producers in the exporting countries. The

lack of such a domestic production in the market for vehicles in Norway is the argument for my analyses of the perfect competition hypothesis.

The first challenge that I face is finding a good proxy for the variable marginal production costs. The reason for that is because data that have been used by Statistics Norway of this variables is no longer available. Therefore, the main contribution from this thesis is the construction of foreign export price in foreign currency indices. To do so I need data on per country import shares and the foreign export prices of the exporting countries. I choose the Törnqvist superlative price index number formulae to construct the foreign price in foreign currency, proxying the production marginal costs because of its feature to capture effects such as effect of price level differences between countries, effects from inflationary impulses and the effects of varying import shares. As so, any problem such as the China effect, that is, effects from the differences in price levels between countries, problem is accounted for using this index number formula. Statistics from 1988 to 2012 on the share of import of vehicles consists of 45 countries, many of which have very little shares of the total imports and have very scarce data statistics. Removing these countries I end up with seven countries that I am to work with. The data period is from quarter one 1990 to quarter four 2012. The merging technique is used where there are not sufficient data and I need to connect several data series. Once the series of foreign prices have been constructed I plug them straight into the Törnqvist price index formula. Doing so we see that the Törnqvist series suffer from base quarter dependency. To overcome this challenge, a chaining technique is utilise. Each of the quarters in the Törnqvist foreign price series is chained to each other by multiplying the former values from the fixed quarter series with the latter values in the series for non-fixed Törnqvist price index, which starts at 1 for the first quarter in 1990.

There are two hypotheses this thesis aim at testing, 1) no pricing to market in the market for vehicles in Norway, and 2) no changes in the pricing behaviour of the exporters after the financial crisis in 2008. Using quarterly and seasonally unadjusted time series data on import prices and export prices in Norwegian Kroner, and the Norwegian unemployment rate together with seasonal dummies and an equilibrium correction mechanism I estimate several equilibrium correction models and develop dynamic forecasting. I find that there is significant estimate of the equilibrium correction term lagged twice and can thereby be seen as sign of cointegration between the import prices and export prices. Cointegration occurs when two or more variables that have unit root, integrated of order one I(1), together forms a linear combination that is stationary, thus do not have unit root, I(0). Cointegration in statistics describe an equilibrium phenomenon where two or more variables move together in co-movements because of their underlying economic forces. From the plots of the variables before and after differencing and from the augmented Dickey Fuller tests, we see that the variables are non-stationary before differencing them once and stationary after. This confirms that they are integrated of order one prior to differencing, and so the cointegration between the import prices and the export prices are said to exist. This means that in the long run, prices of imports will equal prices of

exports. There is no pricing to market in the long run, meaning that changes in the exchange rates or in the marginal costs will be fully absorbed in the import prices through export prices. The estimations also show significant effects of the first lagged period of variables import price and export price, significant effect of the second lagged period of unemployment rate and the seasonal dummies lagged once and twice. Unlike Boug et al. (2005), there is no effects from the unemployment rate on import prices in the long run and the equilibrium correction term is almost twice as negative in magnitude. In the short run there is very little pass through, only 27%, to the import prices from the export prices from a change in the exchange rate or marginal costs. An estimate of negative 0.21 in the equilibrium correction tells us that it will take some time before pass through is complete. The equilibrium models are not spurious equations as implied by the plots and the augmented Dickey Fuller tests. As such the test statistics can be used for hypothesis testing and the conclusions drawn upon the test statistics are credible and valid.

Testing the second hypothesis by means of dynamic forecasting and full sample period versus sample period up to quarter three in 2008, we see that there are no significant changes in the two sample period estimations. The dynamic forecasts, with all 17 observations lie within the +/- 2 standard deviations, show good forecasting ability. Thus, the conclusion is that the pricing behaviour does not appear to have changed significantly after the financial crisis in later 2008.

What has not been done in this thesis is for example testing of weak exogeneity in the Törnqvist price index or perhaps perform formal tests for cointegration. I will leave this for future work due to the time limit and the mandate of this thesis.

Appendix

*P*I: Chained geometric mean price index for imports of motor vehicles, measured in Norwegian currency from 1990 (Q1)-2012 (4). Q1 1990=1. Source: Statistics Norway.

PF_t^T: Törnqvist price index based measure of export prices of motor vehicles, measured in foreign currency from 1990 (Q1)-2012 (4). Q1 1990=1, cf Eq.(9) in the text.

impkr7: Import weighted nominal exchange rate index, a chained geometric mean index for the exchange rate basket based on s_j and the bilateral exchange rates between Norway and Japan, the Euro (Germany, France and Belgium)area, UK, Sweden and USA for 1990 (Q1)-2012 (4). Q1 1990=1. Source: Statistics Norway and Central Bank of Norway.

S_{it}: Value Import Shares of Vehicles from country i (Germany, France, Japan, Sweden, USA, UK and Belgium). Source: Statistics Norway, the Foreign Trade Statistics.

$Seasonal_t$: Seasonal dummies for quarter t

UR: Unemployment rate defined as the number of unemployed as a percentage of the labour force. Source: Statistics Norway, the Labour Force Survey.

PF_France: Consumer Price Index, Purchases of Vehicles, period: 1990 (Q1)-2012 (Q4). Export Price Index, Durable Consumer Goods, period: 2005 (Q1)-2012 (Q4). Export Prices, Manufacturing Products Index, period: 1999 (Q1)-2012 (Q4). Measured in EURO. Source: Macrobond

$PF_Germany$: Producer Price Index on manufacturing, period: 1976 Q1-2012 (Q4). Producer prices index on motor vehicles, period: 1995 (Q1)-2012 (Q4). Measured in EURO. Source: Reuters Ecowin

PF_Japan: Export Prices Index, Passenger Cars, standard passenger cars, period: 1980 (Q1)-2012 (Q4). Measured in Japanese Yen. Source: Macrobond

PF_Sweden: Export Prices Index, Manufactured Products, Motor Vehicles, period: 1990 (Q1)-2012 (Q4). Measured in SEK. Source: Macrobond

PF_USA: Export Prices Index, Automotive Vehicles, passener cars new and used, period: 1982 (Q1)-2012 (Q4). Measured in USD. Source: Macrobond

$PF_UnitedKingdom$: Producer price index, output, motor vehicles, measured in GBP. Source: Macrobond

$PF_Belgium$: Producer Price Index, Output, Motor Vehicles, period: 1996 (Q1)-2012 (Q4). Consumer Price Index, Transport, period: 1990 (Q1)-2012 (Q4). Measured in EURO. Source: Reuters Ecowin

References

[1] Banerjee et al. (1993) *Co-integration, Error Correction and the Econometric Analysis of Non-Stationary Data*. Oxford University Press

[2] Berry, A.M.Levinsohn and Pakes, A. (1995) *Automobile Prices in Market Equilibrium*. Econometrica 63(4), 841-890

[3] Benedictow, A and Boug, P. (2012) *Trade Liberalisation and Exchange Rate pass-through: the case of textiles and wearing apparels*. Empirical Economics, Statistics Norway

[4] Benedictow, A. (2008) *Import pris med Kinaeffekt- en Importprisligning for Tekstil og Bekledningsprodukter*. Statistics Norway

[5] Betts, C. and Devereux, M.B. (1996) *The Exchange Rate in a Model of Pricing to Market*. European Economic Review 40, 1007-1021

[6] Boug, P. (2000) *Modelling Energy Demand in Germany-A Cointegration Approach*. Working Paper, Statistics Norway

[7] Boug et al. (2005) *Exchange Rate Pass-through in a Small Open Economy: The Importance of the Distribution Sector*. Discussion Papers No.429, Statistics Norway

[8] Boug, A. and Dyvi, Y. (2008) *MODAG: En Makroøkonomisk Modell for Norsk Økonomi*. Social and Economic Studies, Statistics Norway

[9] Brauer, H. (2003) *Empirical Results for the Degree of Pass-Through in Domestic and Export Markets. In H.Siebert (ed): The Real Exchange Rate and Prices of Traded Goods in OECD countries*. Ch. D, Springer-Verlag, Berlin

[10] Bresnahan, T.F. (1981) *Departures from Marginal-Cost Pricing in the American Automobile Industry: Estimates for 1977-1978*. Journal of Econometrics 17, 201-227

[11] Campa, J.M. and Goldberg, L. (1999) *Investment, Pass-Through, and Exchange Rates: A Cross-Country Comparison*. International Economic Review 40, 287-314

[12] Choudhri, E.U. and Hakura, D.S. (2001) *Exchange Rate Pass-Through to Domestic Prices: Does the Inflation Environment Matter?*. IMF Working Paper 01/194

[13] Engel, C. (2000) *Local-Currency Pricing and the Choice of Exchange Rate Regime*. European Economic Review 44, 1149-1472

[14] Feenstra, R.C., Gagnon, J. and Knetter, M. (1996) *Market Share and the Exchange Rate Pass-Through in World Automobile Exports*. Journal of International Economics 40, 187-207

[15] Fischer, C. (2010) *Imperfect Competition, Consumer Behaviour and the Provision of Fuel Efficiency in Light-Duty Vehicles*. Resources for the future, DP 10-60

[16] Granger, C.W.J, Newbold P. (1973) *Spurious Regressions in Econometrics*. Journal of Econometrics 2, 111-120, University of Nottingham

[17] Kasa, K. (1992) *Adjustment Costs and Pricing-to-market*. Journal of International Economics 30, 1-30

[18] Khalaf, L. and Kichian, M. (2004) *Pricing-to-market Tests in Instrumental Regressions: Case of the Transportation Equipment Industry*. Empirical Economics 29, 293-309

[19] Knetter, M. (1993) *International Comparisons of Pricing-to-market Behaviour*. American Economic Review 83, 473-486

[20] Krugman, P.R. (1987) *Pricing to Market when the Exchange rate Changes. In W.W.Arndt and J.D.Richardson (eds.)* Real-Financial Linkages among Open Economies, Ch.3, MIT press, Cambridge, MA

[21] Marston, R. (1990) *Pricing-to-market in Japanese Manufacturing*. Journal of International Economics 29, 217-237

[22] Naug, B. and Nymoen, R. (1996) *Pricing to Market in a Small Open Economy*. Scandinavian Journal of Economics, vol.98, issue 3, pages 329-50

[23] Norges Bank (2003) *Beregning av Import Veid Nominell Valutakurver*. Området for Pengepolitikk

[24] Shittu et al. (2012) *On Autoregressive Distributed Lag, Cointegration and Error Correction Model: An Application to Some Nigeria Macroeconomic Variables*. Australian Journal of Business and Management Research, vol.2, issue nr. 8, pages 56-62